

# Yamato 983885

Basalt-bearing anorthositic (polymict) regolith breccia

288.54 g



Figure 1: Yamato 983885 basalt bearing feldspathic regolith breccia; cube is 1 cm on a side.

## Introduction

Yamato 983885 (Fig. 1) was found on bare ice around the Yamato Mountains, on January 11, 1999 during JARE-39 (Fig. 2 and 3). It weighs 288.54 g and has thin yellowish green fusion crust. Angular white and grey clasts and white plagioclase, and darker pyroxene all occur in a fine dark matrix (Fig. 4; Kaiden and Kojima, 2002; 2003).

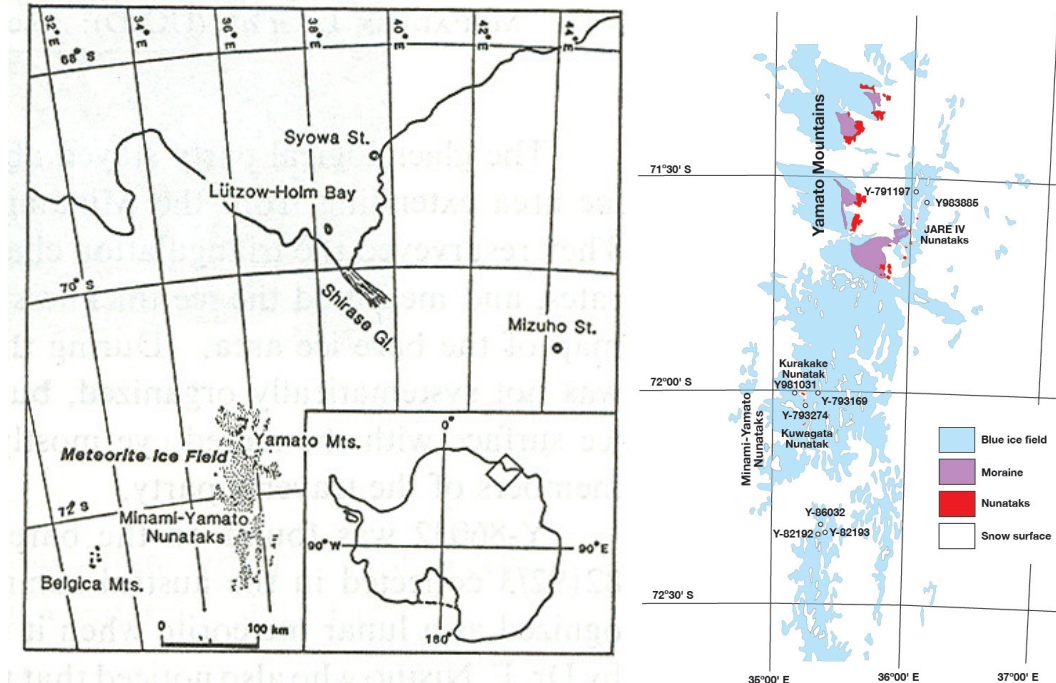
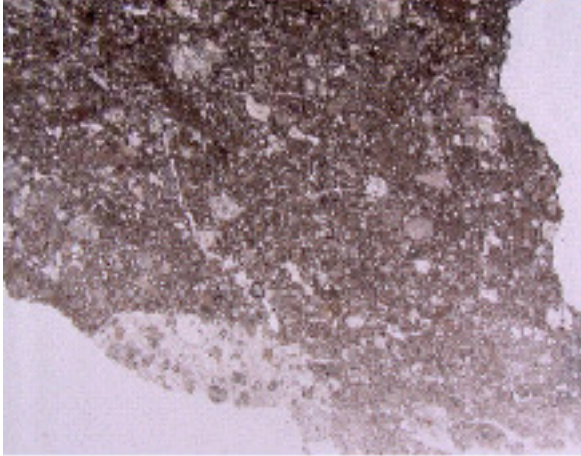


Figure 2: Location map for the Yamato Mountains. Figure 3: Detailed location map for the Yamato lunar meteorites (map courtesy of the NIPR). Y983885 is at the top right of the map.



*Figure 4: six different views of Yamato 983885 ; cube is 1 cm on a side.*



*Figure 5: photomicrograph of Yamato 983885 thin section 71-1, illustrating the preponderance of dark matrix and many small clasts. Width is 7.5 mm.*

### **Petrography and Mineralogy**

This meteorite is a polymict breccia that contains numerous clasts and mineral fragments in a dark brown matrix (Fig. 5). The clasts include monomineralic and polymineralic types, as well as glass spherules (Kaiden and Kojima, 2002; 2003; Arai et al., 2004, 2005). The polymineralic clasts are troctolite, norite, granulite, KREEP basalt, high Al basalt, and low Ti basalt (Fig. 6 and Table 1). The lithologies are largely of highland origin, but the presence of some basaltic material indicates that this is a mixed breccia with similarities to Calalong Creek or MET 01210. The fine grained matrix makes up close to 95% of the mode of the rock, as can be seen in two different thin sections (Fig. 5 and 6). A detailed study of six of the clasts by Arai et al. (2005) has led to a thorough understanding of the mineralogy and petrology of this breccia. The narrow compositional range of plagioclase feldspar, pyroxene, and olivine in the small clasts of troctolite, norite, and high Al basalt (Fig. 7 and 9) are shown in Figure 8 and 10. Whereas the much larger compositional range of plagioclase and pyroxene in the low Ti and KREEP basalt (Fig. 11 and 13) are shown in Figures 12 and 14.

**Table 1: Modal abundance of each clast in Y983885 (from Arai et al., 2005)**

<i>Clast</i>	<i>Plag.</i>	<i>pyrox</i>	<i>oliv</i>	<i>ilm</i>	<i>chrom</i>	<i>K-spar</i>	<i>Sil+gl</i>	<i>Sulf+Met</i>	<i>phos</i>
<i>KREEP</i>	64.1	20.1	-	2.1	-	tr	10.9	-	2.8
<i>Norite</i>	48.8	40.4	10.8	-	-	-	-	-	-
<i>Troct.</i>	59.6	15.5	23.4	-	tr	-	-	1.5	tr
<i>Gran.</i>	91	-	9	-	-	-	-	-	-
<i>Hi Al</i>	75.4	10.6	10.9	-	-	-	-	2.7	0.4
<i>VLT</i>	42.5	53.4	tr	tr	-	-	4.1	-	-

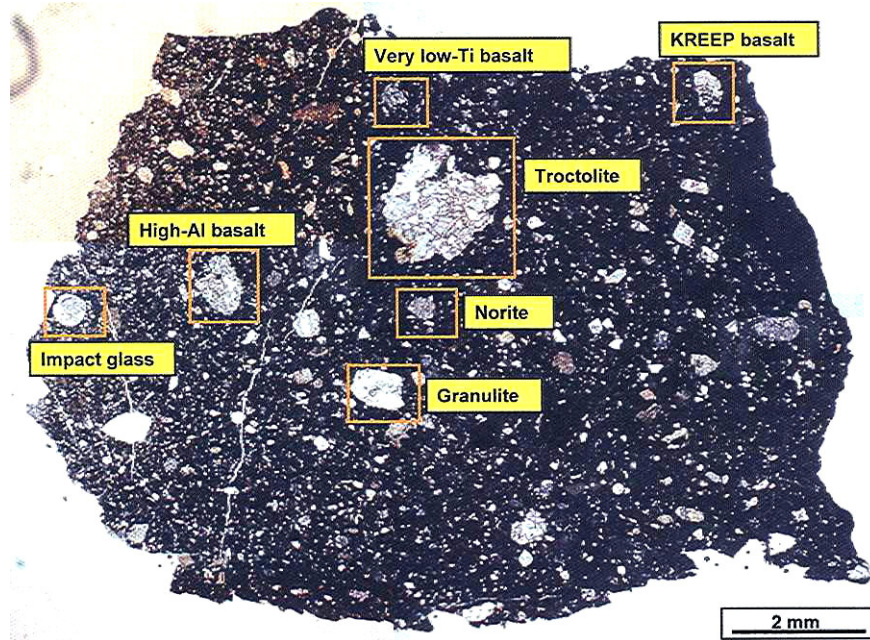


Figure 6: Photomicrograph of thin section 59-2, from the study of Arai *et al.* (2005), illustrating the diversity of small clast lithologies present in Yamato 983885.

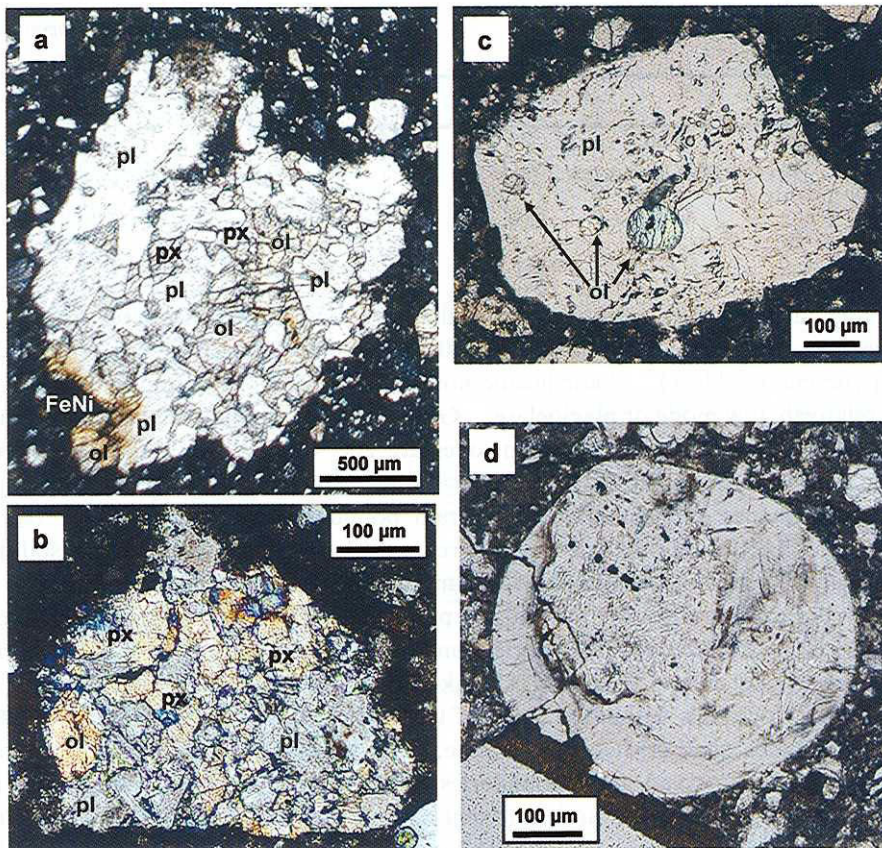


Figure 7: Close up views of four different clasts: a) troctolite, b) norite, c) granulite, and d) impact spherule.

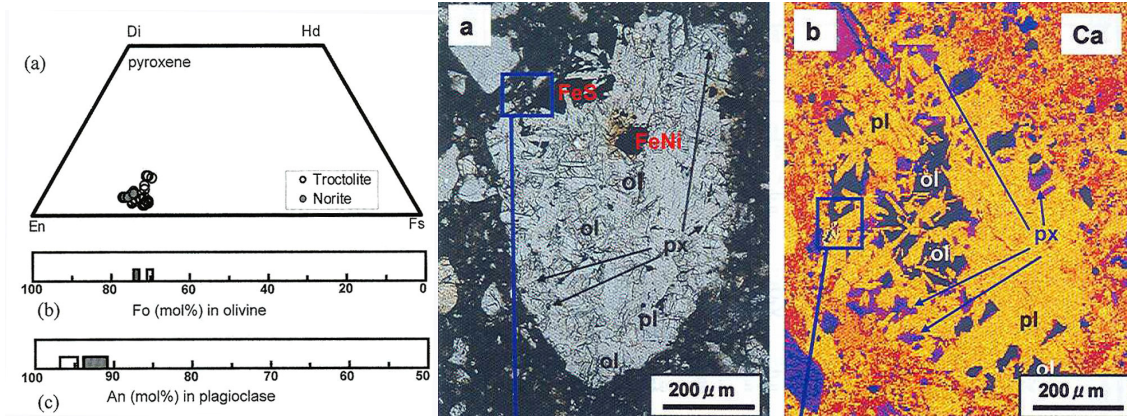


Figure 8: Pyroxene, olivine and plagioclase compositions from the troctolite and norite from Fig. 7. Figure 9: Photomicrograph (a) and Ca x-ray map (b) of high Al basalt clast.

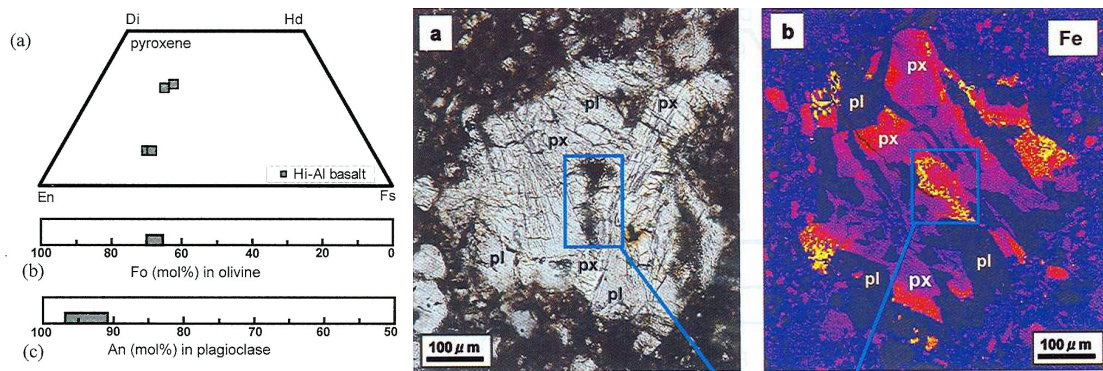


Figure 10: Pyroxene, olivine and plagioclase compositions from the high Al basalt clast of Fig. 9. Figure 11: Photomicrograph and Fe x-ray map of VLT basalt clast. Blue boxes are from the original work, and highlight patches of silica, fayalite, ilmenite and troilite.

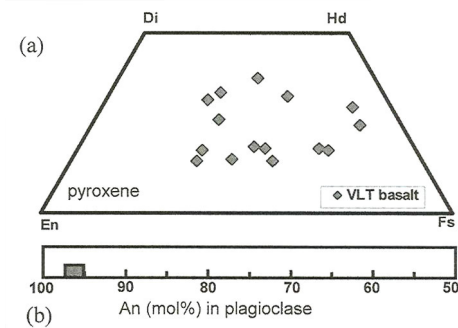


Figure 12: pyroxene and plagioclase compositions from the VLT basalt clast of Figure 11. Note much wider range of pyroxene composition compared to the other plutonic rocks – similar to that observed in Apollo VLT basalts.

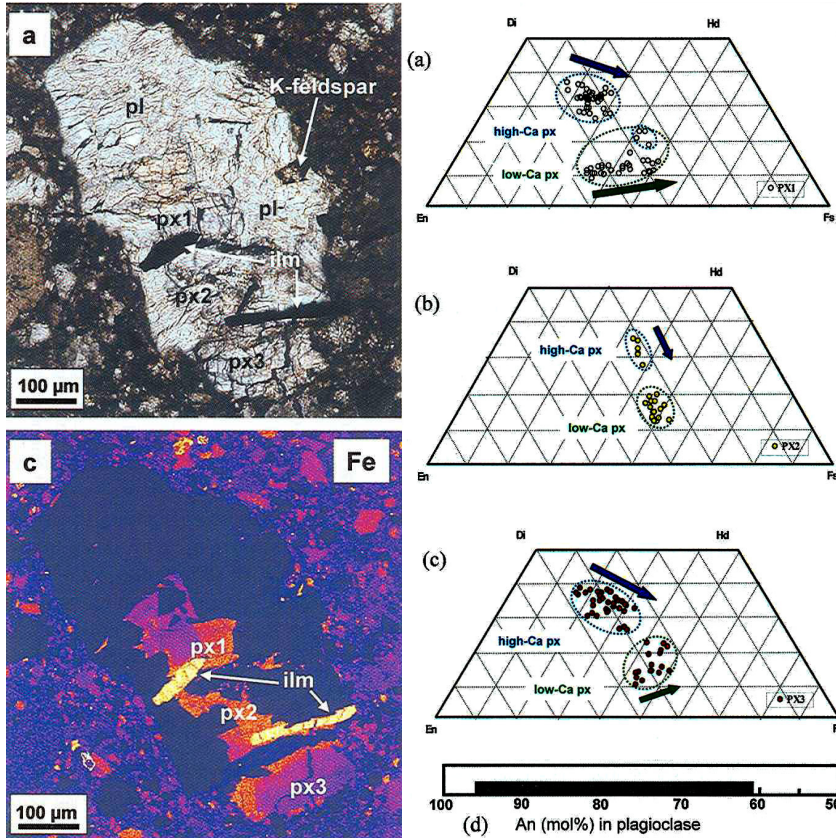


Figure 13: Photomicrograph and Fe x-ray map of KREEP basalt clast. Figure 14: Pyroxene px1, px2 and px3, together with plagioclase compositions from the KREEP basalt clast of Fig. 13.

### **Chemistry**

The petrographic evidence for a mixed breccia (dominated by highlands components) is reinforced by the bulk compositional features of Yamato 983885 (Table 2). It has a similar composition to Calalong Creek, in that it contains 9 to 10 wt% FeO and 21 to 22 wt% Al<sub>2</sub>O<sub>3</sub> (Fig. 15). A small KREEP component is evident with its rare earth element concentrations elevated above those of feldspathic breccias such as Y791197, but still lower than the KREEP-rich SaU169 (Fig. 16; Warren and Bridges, 2004). Yamato 983885 also contains high noble gas contents, and a solar wind component suggesting a higher maturity than many other lunar regolith breccia meteorites (Fig. 17; Miura et al., 2006).

Comparison of lunar meteorite bulk compositions to the Lunar Prospector Gamma Ray Spectrometer data have enabled Corrigan et al. (2009) to propose that Yamato 983885 (as well as Dhofar 961 and Calalong Creek) could be from the South Pole Aitken (SPA) basin region of the Moon. In particular the high Si, and the Ca and K of Yamato 983885 and SPA are good matches.

### **Radiometric age dating**

Phosphates from various portions of the meteorite have been dated using ion microprobe U-Pb approach (S. Arai et al., 2008). Although the phosphate grains are from various

clasts (and therefore possibly of different origins), the obtained data yielded ages of ~4.0 Ga.

### **Cosmogenic isotopes and exposure ages**

Noble gas contents of Yamato 983885 are high, indicating derivation from a mature regolith (Miura et al., 2006; Lorenzetti et al., 2003). Be, Al, and Cl isotopic measurements have yielded the following history for Yamato 983885: ejection from Moon at 0.045 Ma (Nishiizumi et al., 1994), with a very short Earth-Moon transfer time (< 0.02 Ma), and terrestrial age (0.045 Ma).

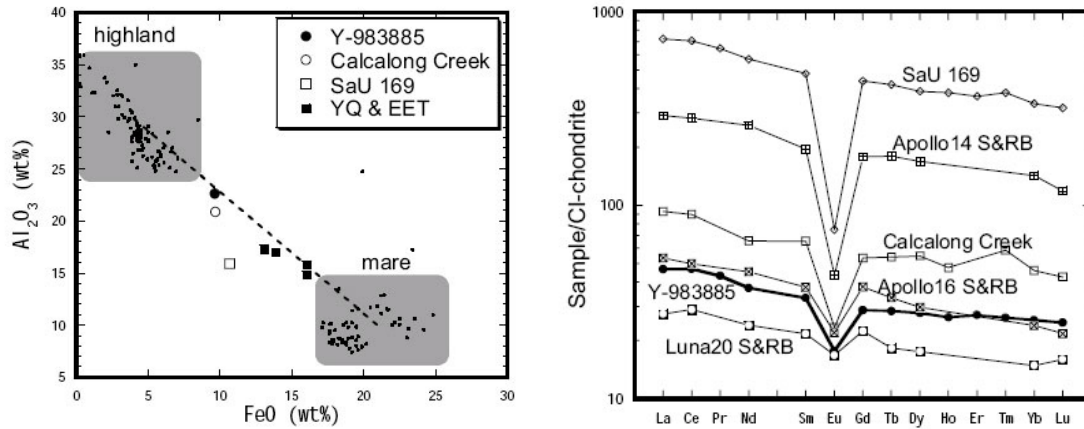


Figure 15: FeO vs.  $Al_2O_3$  for several mingled breccias, including Yamato 983883, from the study of Karouji et al. (2006).

Figure 16: Rare earth element diagram for Y-983885 compared to SaU169, Calalong Creek, and Apollo 14, 16 and Luna 20 soil and regolith breccias (from Karouji et al., 2006).

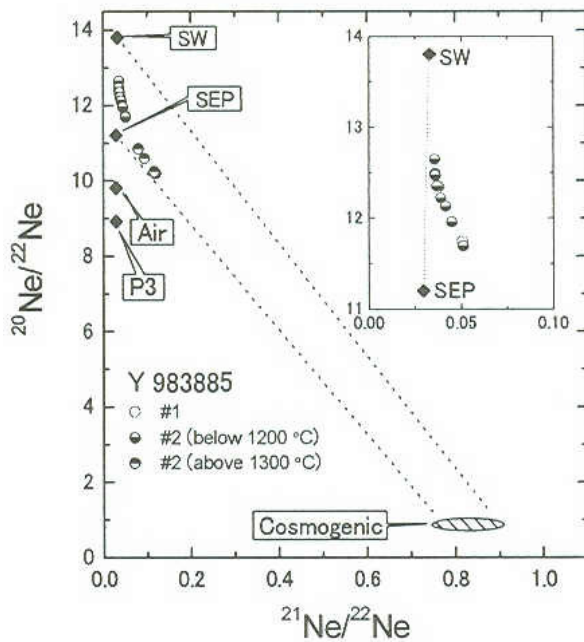


Figure 17: Neon isotopic values for Yamato 983885 (from Miura et al., 2006) illustrating the high solar wind component that is prevalent in all the noble gases for this meteorite.

**Table 1a. Chemical composition of Yamato 983885**

<i>reference</i>	1	2	3	4	4
<i>weight</i>		211	220	107	20-60
<i>technique</i>	a	b,c,d	d	d	e
SiO <sub>2</sub> %	45.59	45.8			46.1
TiO <sub>2</sub>	0.53	0.531			0.45
Al <sub>2</sub> O <sub>3</sub>	21.81	22.6	22.3		22.5
FeO	9.41	9.65			8.56
MnO		0.115	0.121		0.11
MgO	7.98	9.07			8.13
CaO	14.02	13.8			13.5
Na <sub>2</sub> O		0.37			0.37
K <sub>2</sub> O		0.166			0.13
P <sub>2</sub> O <sub>5</sub>					0.08
S %					
<i>sum</i>					100.1
Sc ppm			19.8	19.4	
V			45		
Cr		1347.895	1430	1490	
Co				40.3	
Ni				533	
Cu					
Zn					
Ga					
Ge					
As				<0.4	
Se				n.a.	
Rb				<6	
Sr				130	
Y					
Zr				123	
Nb					
Mo					
Ru					
Rh					
Pd ppb					
Ag ppb					
Cd ppb					
In ppb					
Sn ppb					
Sb ppb					
Te ppb					
Cs ppm				0.2	
Ba				116	
La				9.32	
Ce				24.4	

Pr			
Nd			13.6
Sm			3.68
Eu			0.83
Gd			
Tb			0.911
Dy			
Ho			
Er			
Tm			
Yb			3.67
Lu			0.511
Hf			3.36
Ta			0.46
W ppb			
Re ppb			
Os ppb			
Ir ppb		22	23.3
Pt ppb			
Au ppb			8.1
Th ppm	2.37		2.1
U ppm	0.697		0.55

*technique (a) wet chemistry, (b) ICP-MS, (c ) PGA, (d) INAA, (e) EMPA*

1) Kaiden and Kojima (2002); 2) Karouji et al (2006) 3) Warren and Bridges (2004); 4) Korotev et al. (2009b)

## K. Richter – Lunar Meteorite Compendium - 2010